# Fermilab's Contributions to CDF Physics

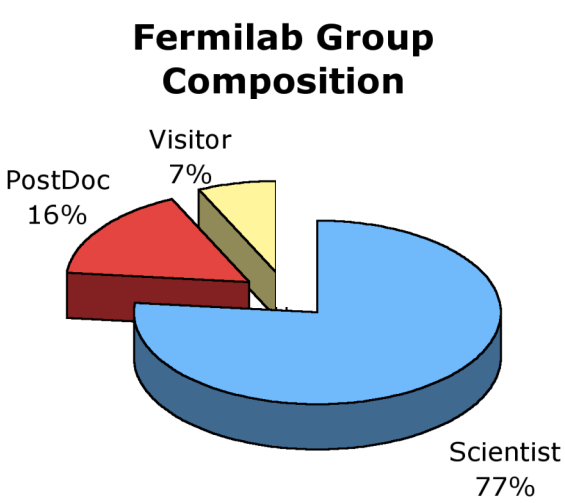
R.J. Tesarek

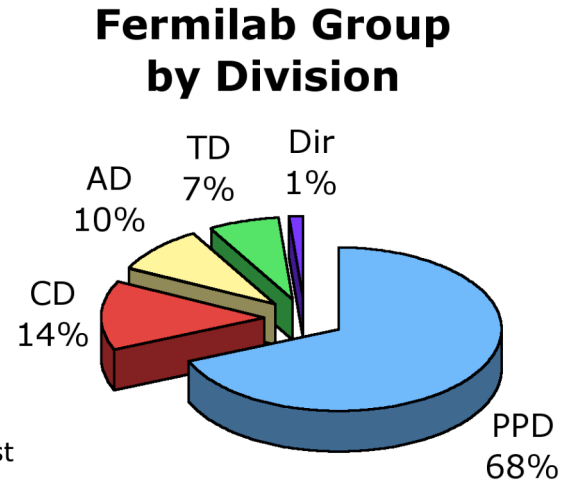
9/26/07

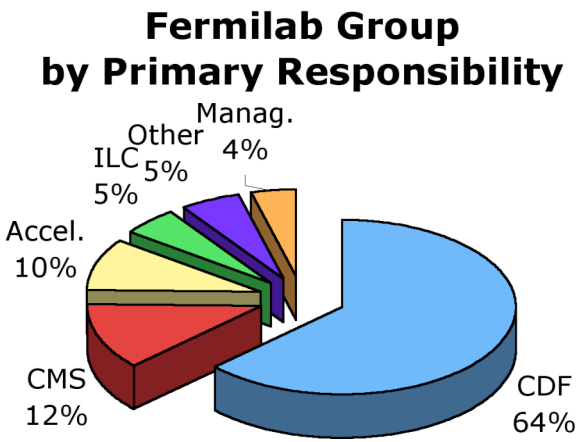
D.O.E Program Review

# CDF:

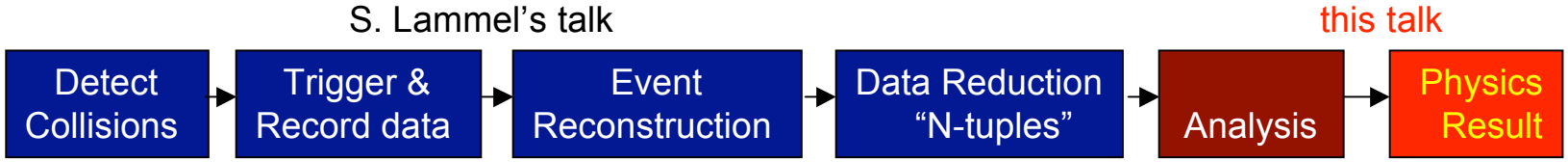
- **International Collaboration**
  - 635 authors, 62 institutions
  - N. America, Europe, Asia
- **Fermilab is the largest single group**
  - 73 members: 56 scientists, 12 postdocs, 5-10 visitors
  - All FNAL divisions represented
  - Responsibilities throughout the lab



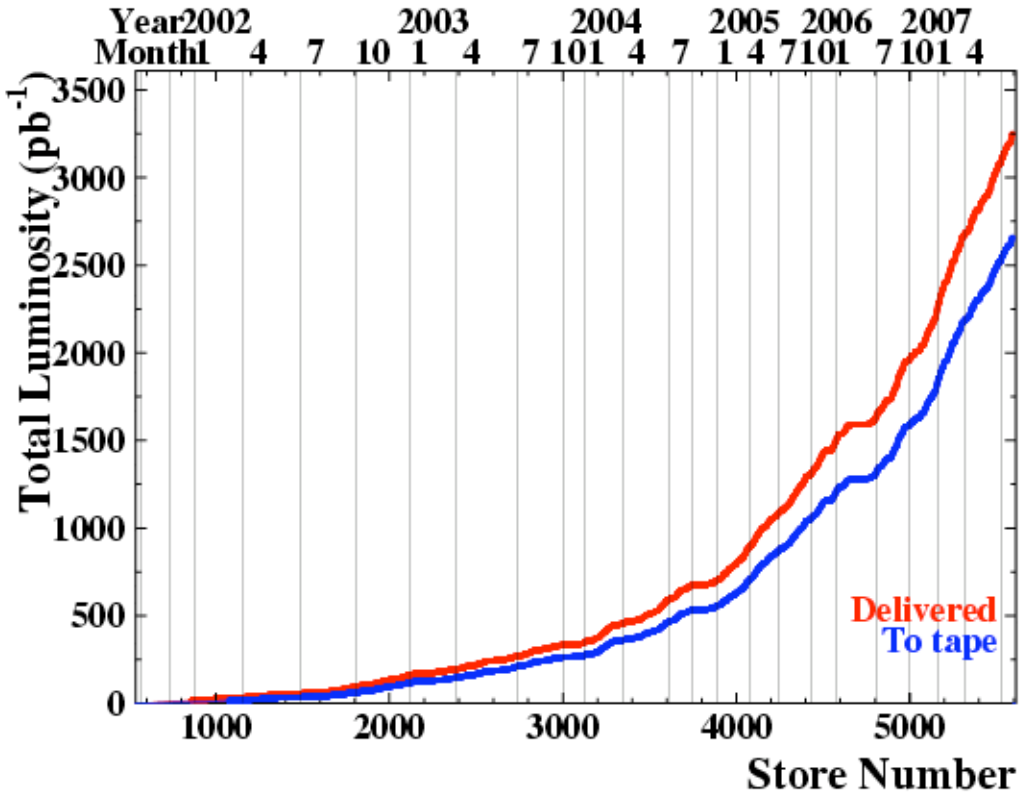
# Getting to Physics




- **Detector Operations**
  - **21 detector group leaders, 10 from Fermilab**
- **Data processing/handling**
  - **5 offline leaders, 3 from Fermilab**
- **Analysis**
  - **13 physics group leaders 4 from Fermilab**
- **Fermilab resources and leadership at all stages**

# Accel./ Detector Performance

- Challenge : maintain detector performance in high luminosity environment
- Opportunity: extract compelling physics from the rapidly increasing data samples
- >250 $fb^{-1}$ data in hand
  - 2 fb-1 analyses out this summer: lead by Fermilab physics coordinator

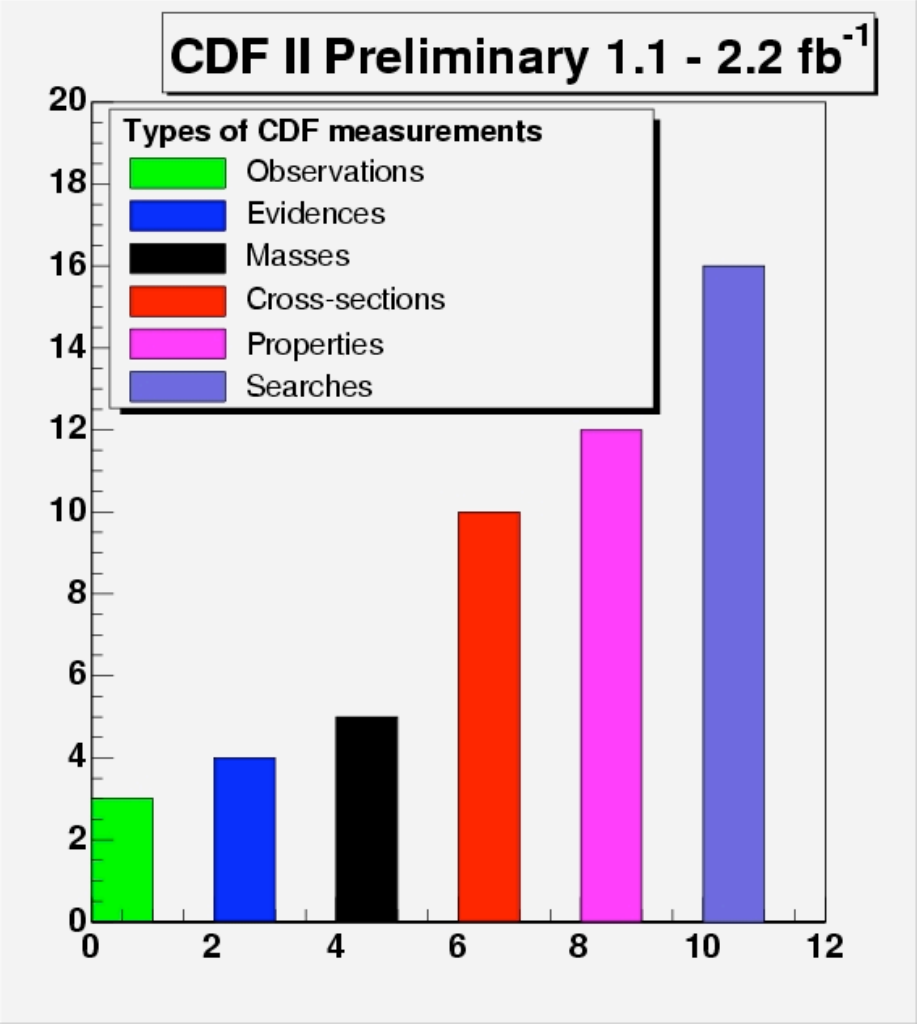


# Physics Metrics

- **Number of Publications**
  - Last year: 93 analyses, 45 papers submitted, 28 published
  - 24 (25%) analyses with FNAL contributions
- **Conference Proceedings**
  - Summer Conference Results:
    - 49 analyses, 267 primary authors, 31 FNAL
- **Tenure Track/Permanent positions**
  - Last year: 2 left (2 national lab)
  - Last 3 years: 12 left (9 faculty + national lab)

# New Physics Results (2007)

- Broad physics program
- 18/51 (37%) analyses with contributions from FNAL group
- Many analyses use 2 $fb^{-1}$ datasets




Ref: Fermilab Today 16 Aug, 2007

# CDF Analyses

| B Physics | Lum. (fb-1) |
|---|---|
| Observation of Bc->J/ψ π, Precise Mass measurement | 2.2 |
| Observation of the Ξ_b | 1.9 |
| Measurement of ΔΓ_s/Γ_s, φ_s using Bs->J/ψ φ | 1.9 |
| Search for FCNC Bs(d)->μ+μ− Decays | 1.9 |
| Orbitally Excited B mesons (B**) | 1.7 |
| Observation of Bs -> Ds K | 1.2 |
| Evidence for D0-D0bar Mixing | 1 |
| **Electroweak Physics** | |
| Measurement of the WZ Production Cross Section | 1.9 |
| Anomalous Coupling Limits from WZ events | 1.9 |
| Evidence for ZZ Production | 1.5 |
| Measurement of dσ(Z/γ* -> e+e-)/dy | 1.1 |
| Measurement of the W-Charge Asymmetry | 1 |
| Direct Measurement of the Z-Boson Invisible Width | 1 |
| **Exotic Physics** | |
| Search for Anomalous Production of γγ τ | 2 |
| Search for Direct Production of Squarks and Gluinos | 1.4 |
| Search for Heavy Quarks in Dileptons+X | 1.2 |
| Global Search for New Physics at High-pT | 1 |
| Search for Large Extra Dimensions using MET+1 Jet | 1 |
| Search for high mass resonance decaying to e+e- | 1 |

| Higgs Phyiscs | Lum(fb-1) |
|---|---|
| Search for H-> W+W- Events | 1.9 |
| Search for WH -> lν bb Events | 1.7 |
| Search for ZH -> νν bb Events | 1.7 |
| Search for hbb in Events with at least 3 B-tags | 1 |
| Updated CDF SM Higgs Combination | 1 |
| Updated CDF+D0 SM Higgs Combination | 1 |
| **QCD Physics** | |
| Inclusive Z+Jets Cross Section | 1.7 |
| Measurement of the Inclusive Z+bjet Cross Section | 1.5 |
| Inclusive Jet Cross Section using MidPoint Algorithm | 1 |
| Measurement of b-bbar Differential Cross Sections | 0.26 |

# CDF Analyses

| Top Physics | Lum (fb-1) |
|---|---|
| Evidence for Single-Top Production using ME Discriminant | 1.5 |
| Search for Single-Top Production using Likelihood Discriminant | 1.5 |
| Mt in Lepton plus Jets events using KDE | 1.7 |
| Mt in Dilepton events using ME | 1.9 |
| Mt in Dilepton events using KDE | 1.9 |
| Mt using lepton-pT | 1.9 |
| First Measurement of W+c Cross Section | 1.8 |
| W-Helicity Fractions in ttbar decays using an Unfolding Method | 1.7 |
| W-Helicity Fractions in ttbar decays using a Template Method | 1.7 |
| $A_{FB}$ in ttbar events | 1.7 |
| Top Quark Charge | 1.5 |
| top-quark Width and Lifetime | 1 |
| Mt in Dilepton events using Templates & ttbar Pz & X-Section Constraint | 1.2 |
| Mt in Dilepton events using Templates and ttbar Pz | 1.2 |

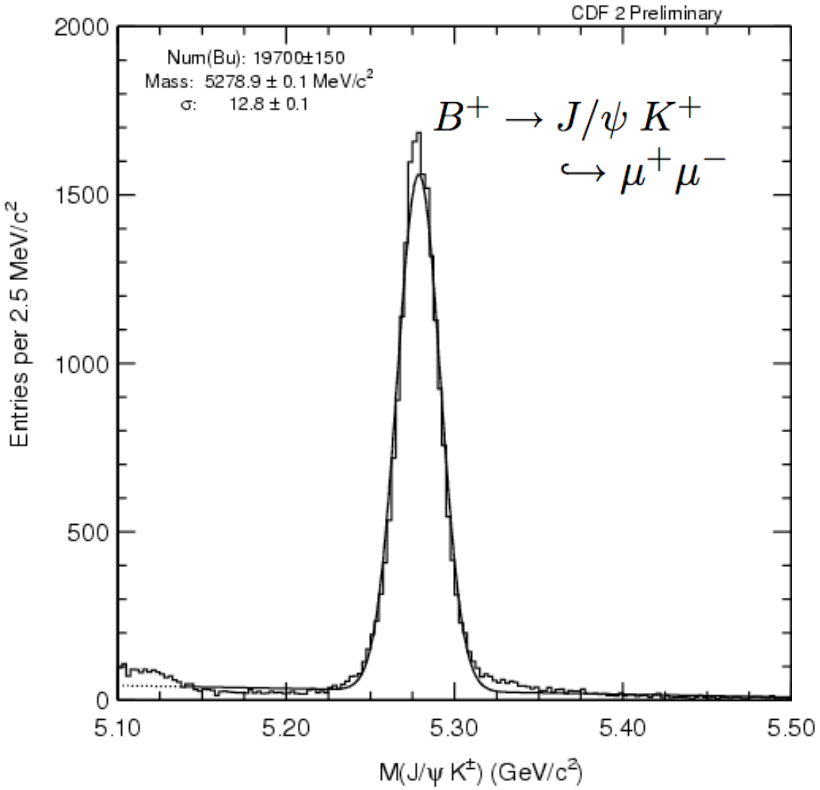
| Top Physics | Lum (fb-1) |
|---|---|
| ttbar Cross Section using lepton plus jets events with a Btag | 1.1 |
| ttbar Cross Section using ee, μμ, eμ Dilepton events | 1.2 |
| ttbar Cross Section using e/μ plus track events | 1.1 |
| ttbar Cross Section using e/μ plus track plus Btag events | 1.1 |
| Fraction of gg-> ttbar events using low pT tracks | 1 |
| Fraction of gg-> ttbar events using NN Discriminant | 1 |
| Search for the FCNC Decays t -> Zq | 1.1 |
| Search for W' -> tb Events | 1 |

# CDF Analysis Selected Topics

## Summary of recent analyses by FNAL personnel

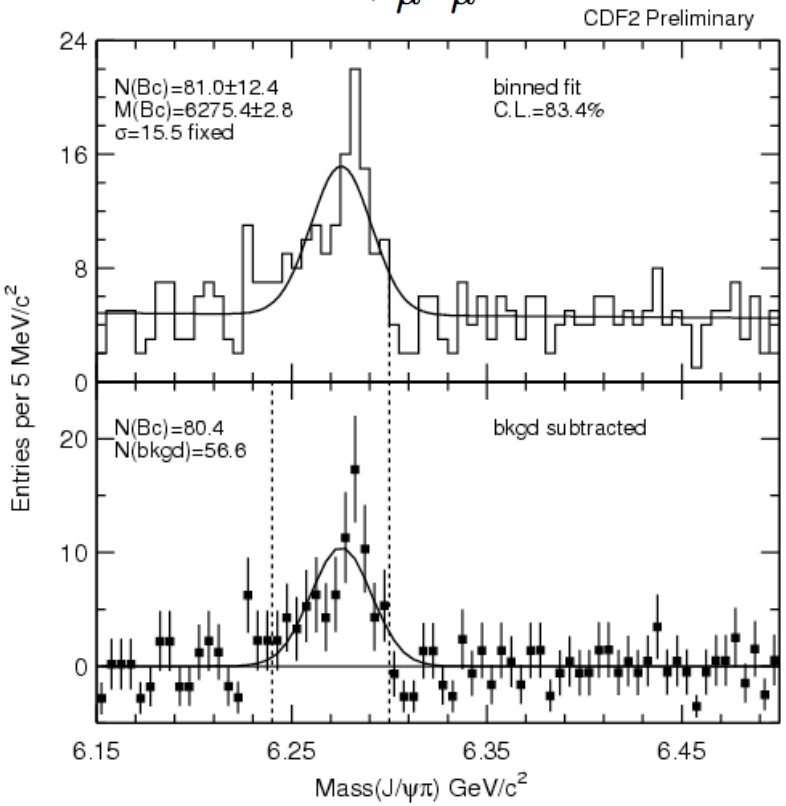
# Precise $B_c^+$ Mass Measurement

- **Last expected ground state meson to be observed**
- **Trigger improvements aided measurement**




W. Wester, S. Tkaczyk, P.Lukens

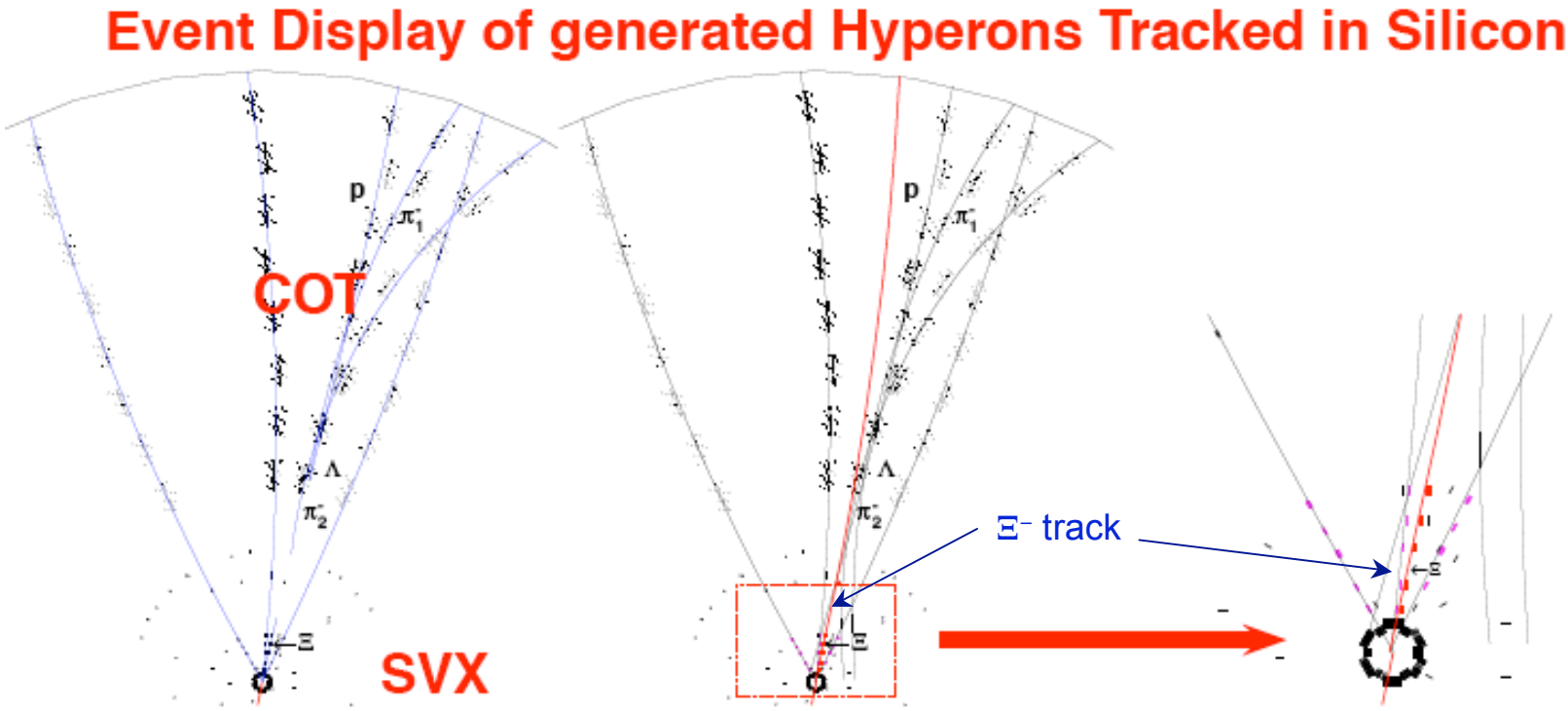
$B_c^+ \to J/\psi\, \pi^+$
$\hookrightarrow \mu^+\mu^-$




$6274 \pm 3.2(stat) \pm 2.6(syst)\ \mathrm{MeV/c^2}$

# Technology Development

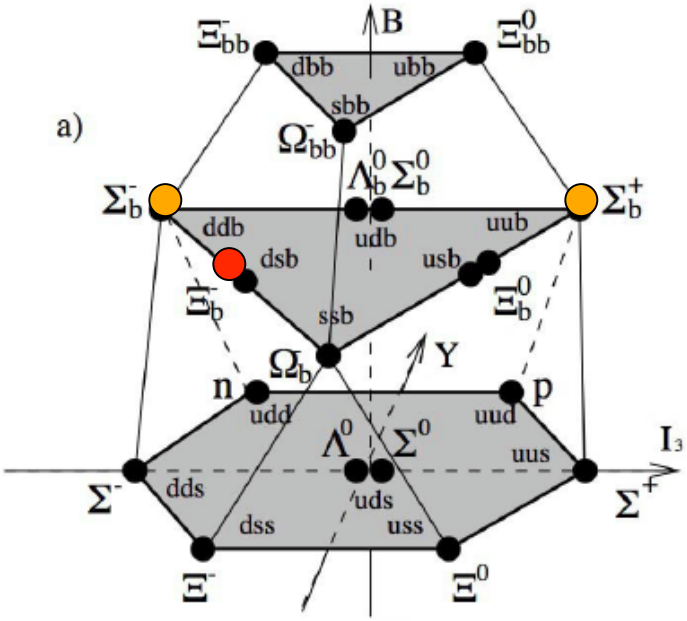
Tracking hyperons in the CDF silicon detector

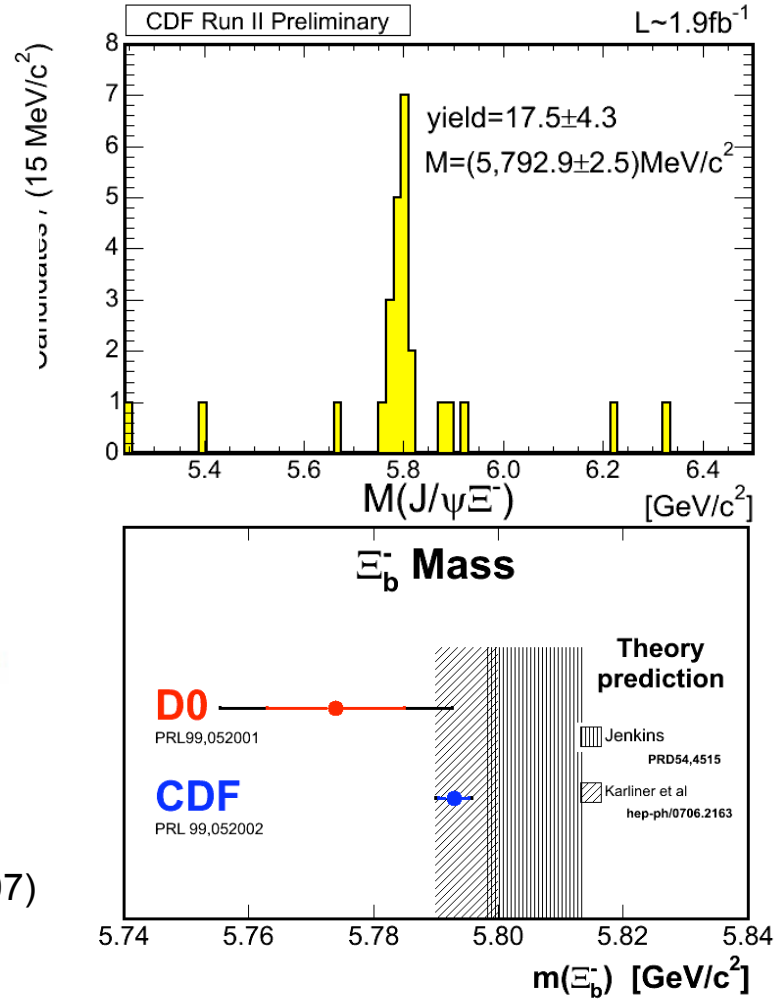



P. Lukens, D. Litvintsev

# $\Xi_b^-$ Observation

- **Baryon containing 3 quark generations**



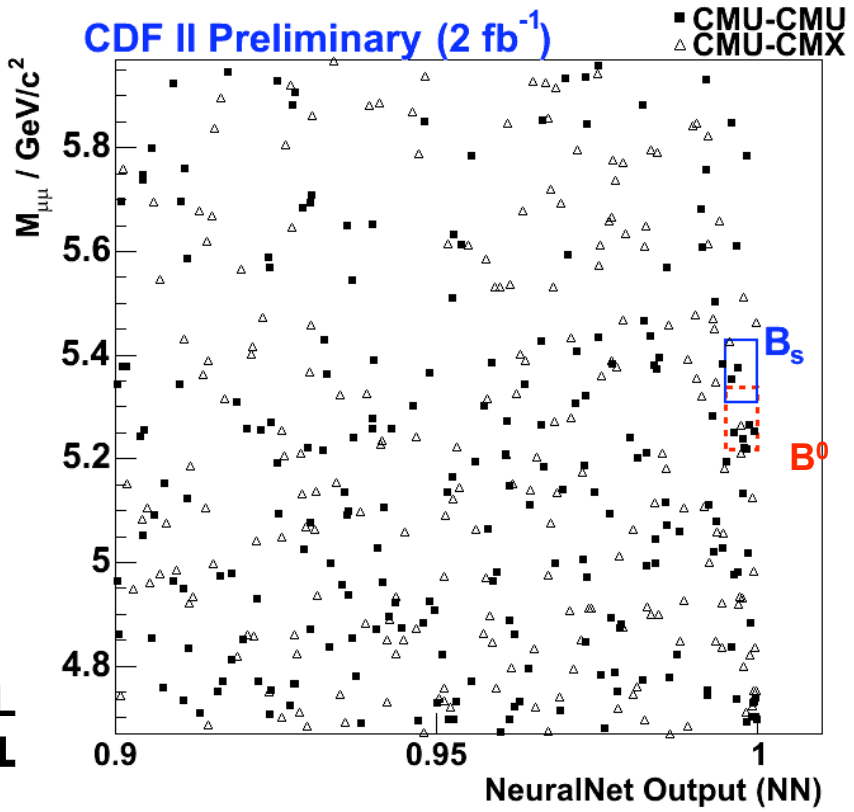

P. Lukens, D. Litvintsev PRL 99 052002 (2007)

D. Litvintsev, R.J. Tesarek (2006)

# $B_s, B^0 \rightarrow \mu^+\mu^-$

- **FCNC, enhanced by non- standard model physics**
- **S.M predicts:**
  - **BR($B_s \rightarrow \mu\mu$) ~$10^{-9}$**
  - **BR($B^0 \rightarrow \mu\mu$) ~$10^{-10}$**

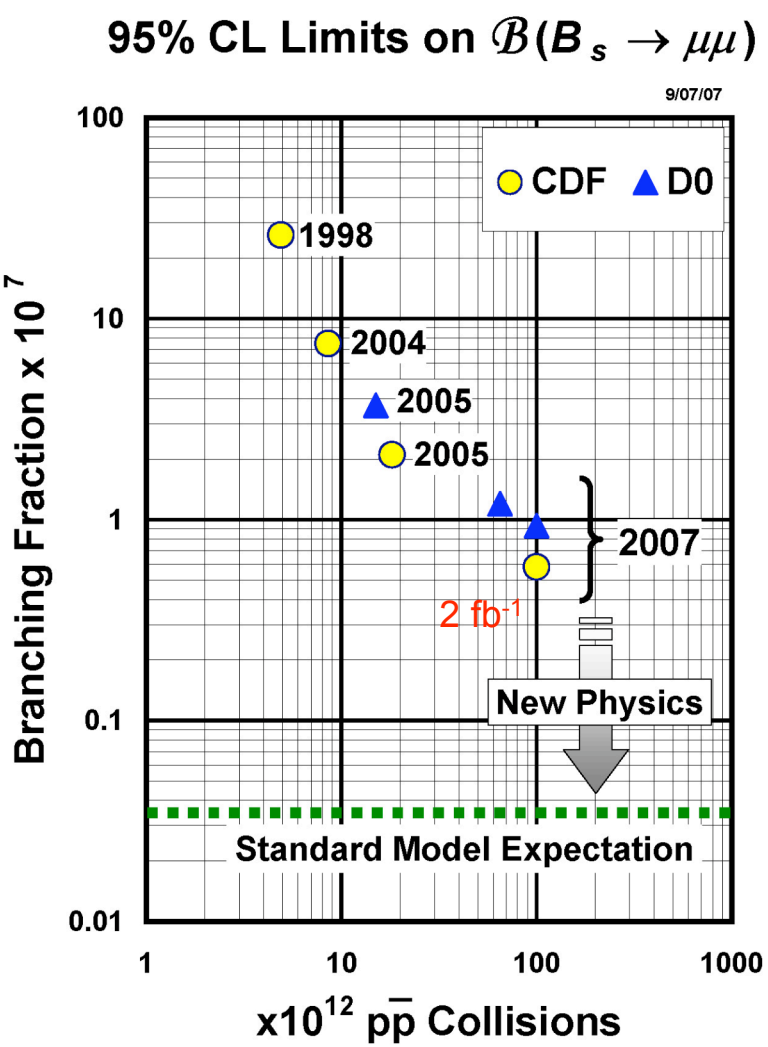
C-J Lin, D. Glenzinski, *et al.*

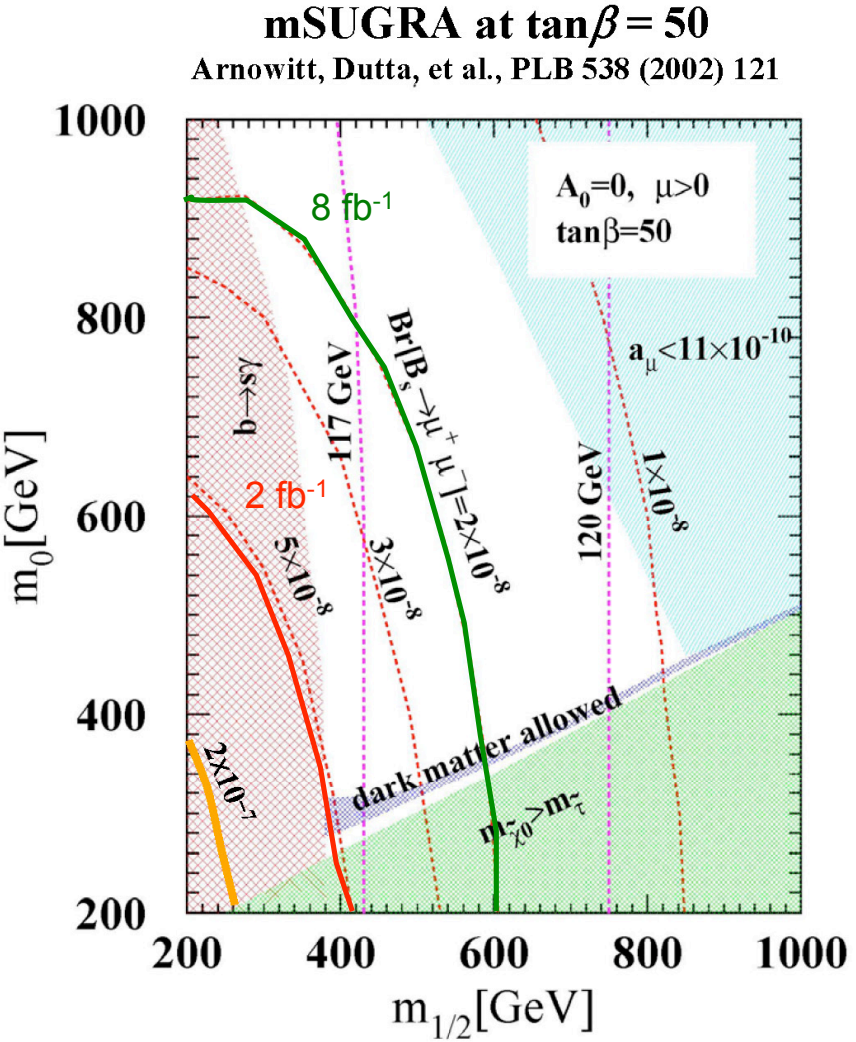



Worlds best limits

**BR( $B_s \rightarrow \mu\mu$ ) < 5.8x$10^{-8}$ @95% CL**
**BR( $B^0 \rightarrow \mu\mu$ ) < 1.8x$10^{-8}$ @95% CL**

# $B_s \rightarrow \mu\mu$ Prospects

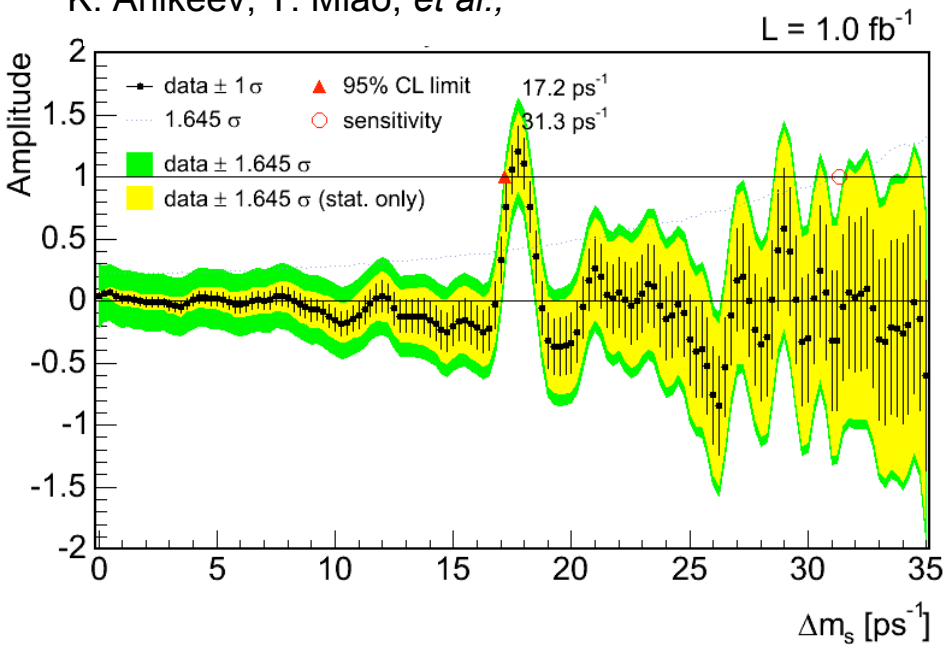


# $B_s$ Mixing

- 3s evidence to 5s observation with same data
  - Increase Bs signal yield
    - Neural net signal selection increases signal/background
    - Additional decay modes added
  - Improve flavor identification at production

K. Anikeev, T. Miao, *et al.,*




$$\Delta m_s = 17.77 \pm 0.10(stat) \pm 0.07(sys)$$

$$\frac{|Vtd|}{|Vts|} = 0.2060 \pm 0.0007(exp)^{+0.0081}_{-0.0060}(th)$$

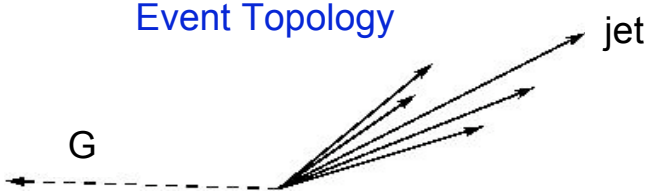
# Large Extra Dimensions (LED)

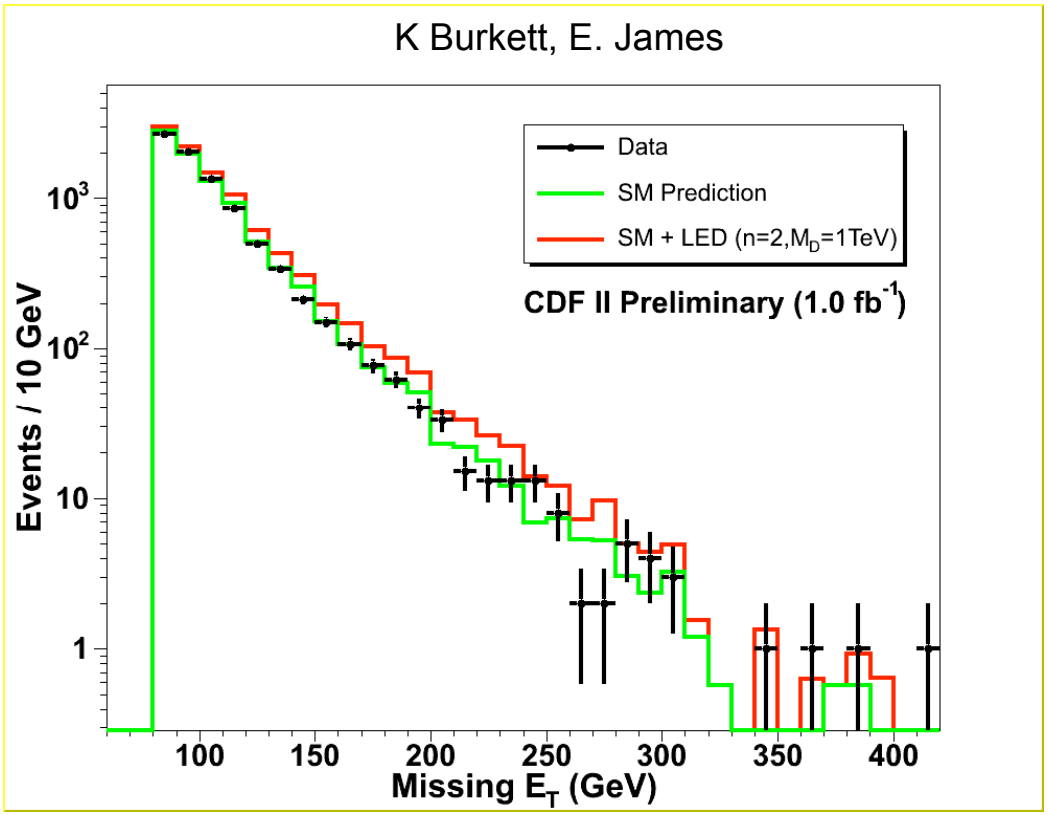
- **Compactified LED produce gravitons**

$$q\bar{q} \rightarrow gG$$
$$qg \rightarrow qG$$
$$gg \rightarrow gG$$

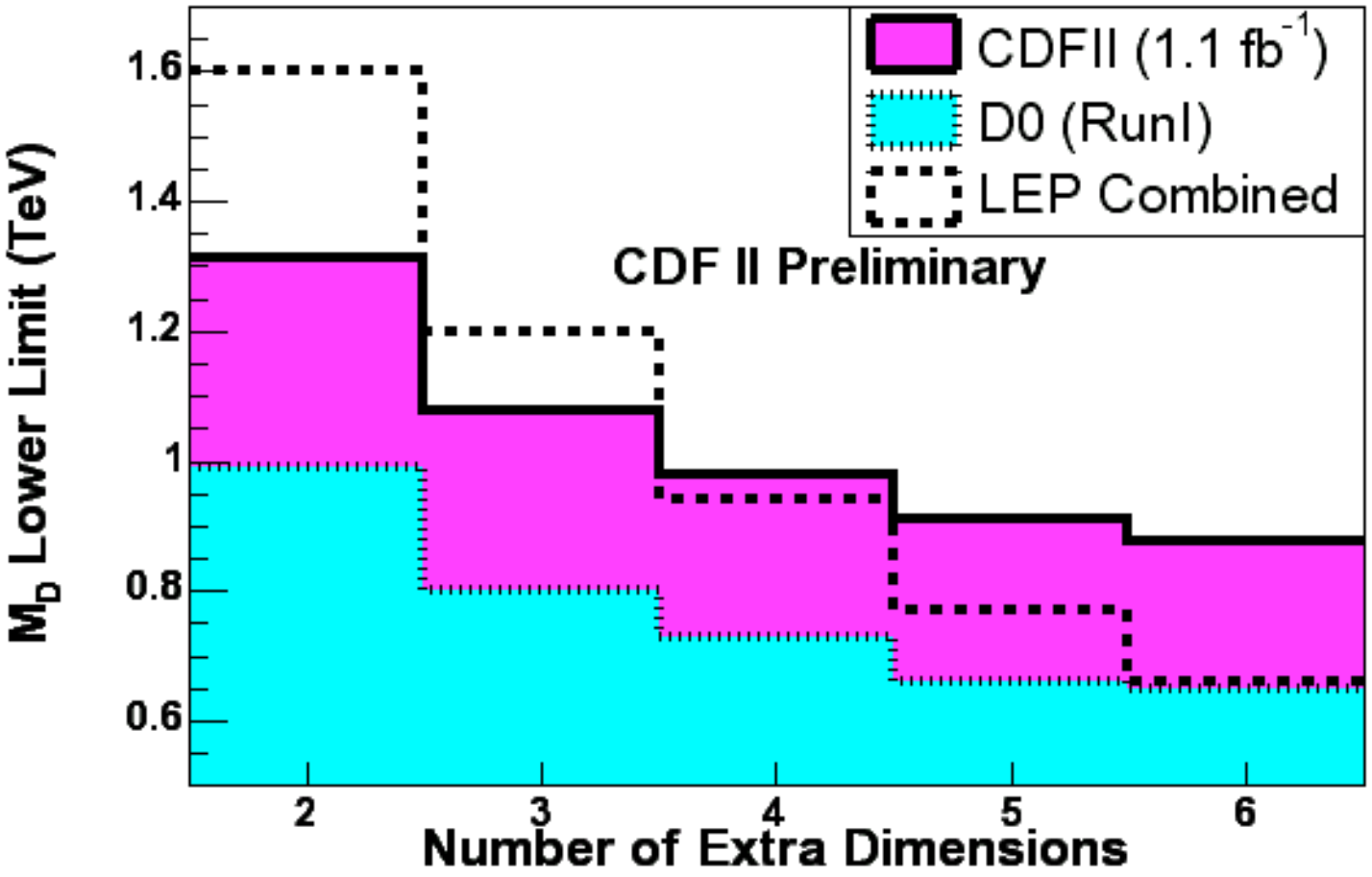
  - **Graviton not detected**
- **Signature: jet+Missing $E_T$**

Event Topology



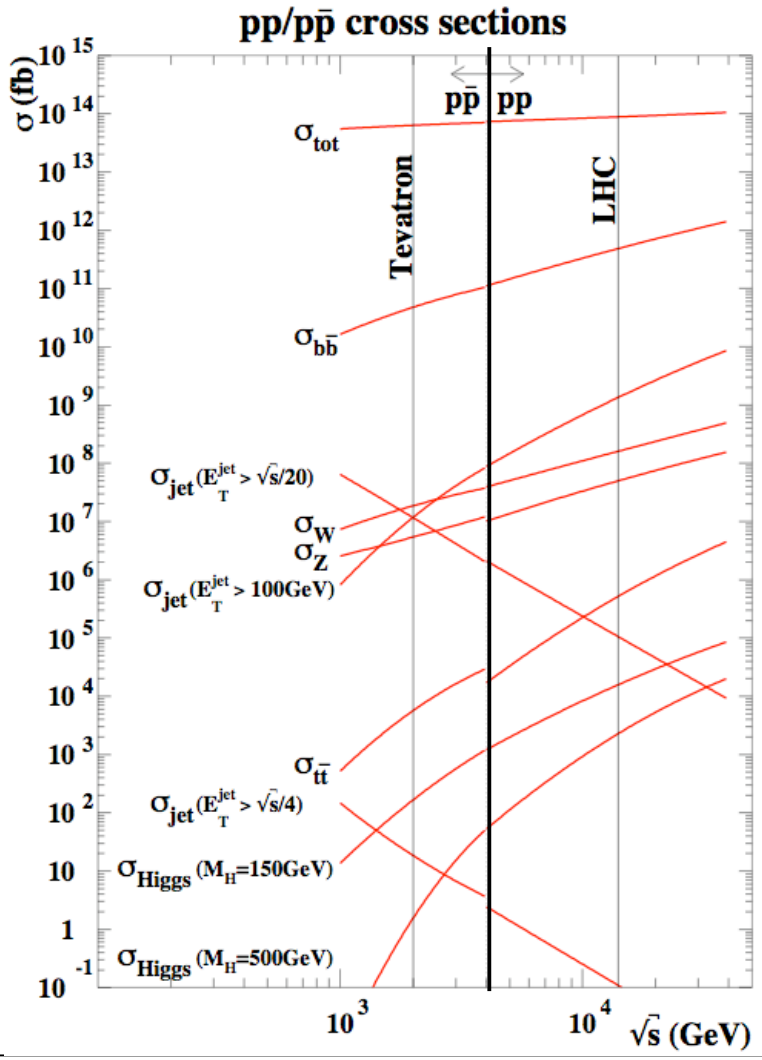



# Large Extra Dimensions Limit



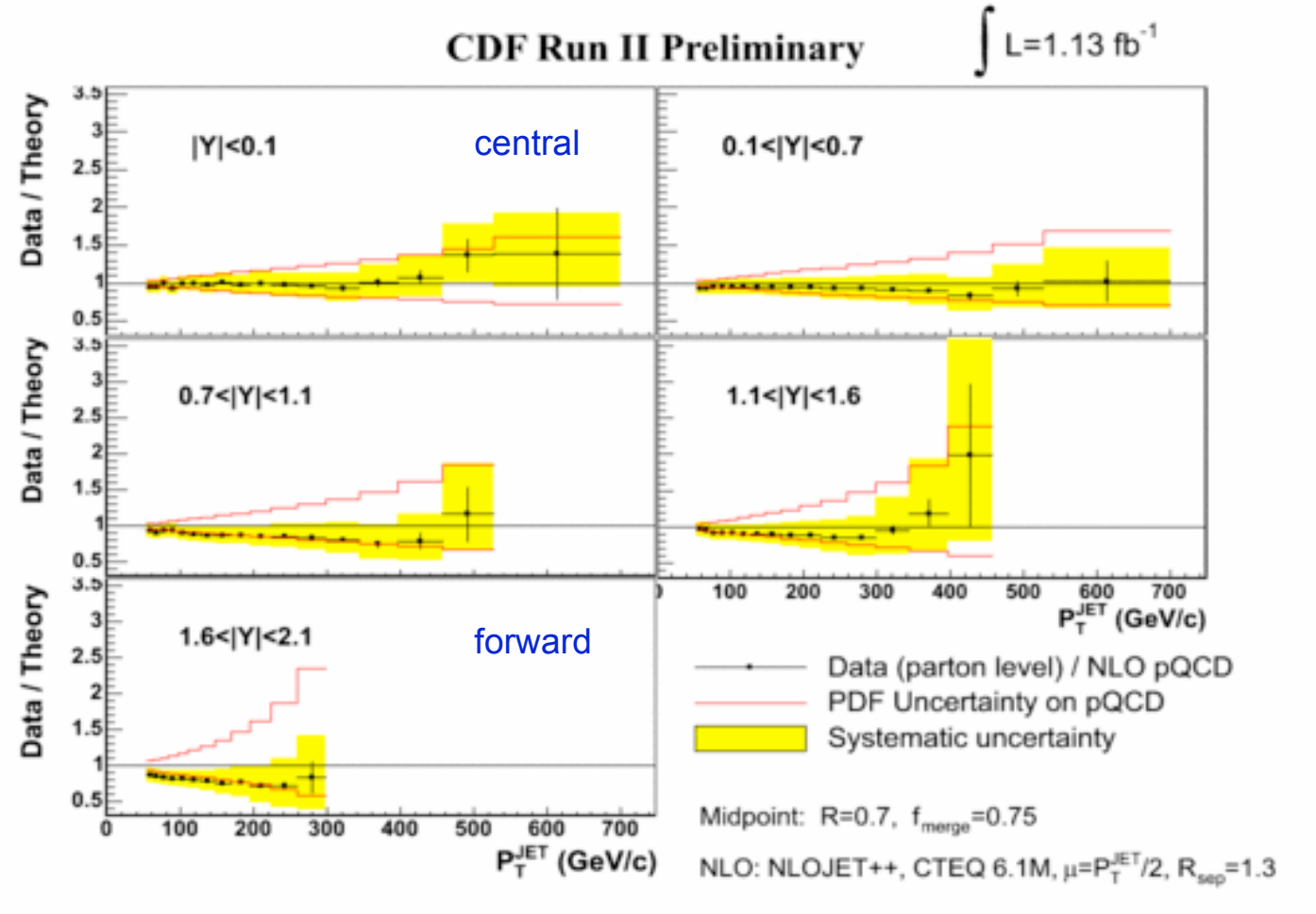
# Jet Cross Sections

- Large cross section process depends on parton density functions (PDF)
- Background to:
  - Top quark production
  - Higgs
  - Non Standard Model physics




C. Group, F. Chlebana, *et al.,*

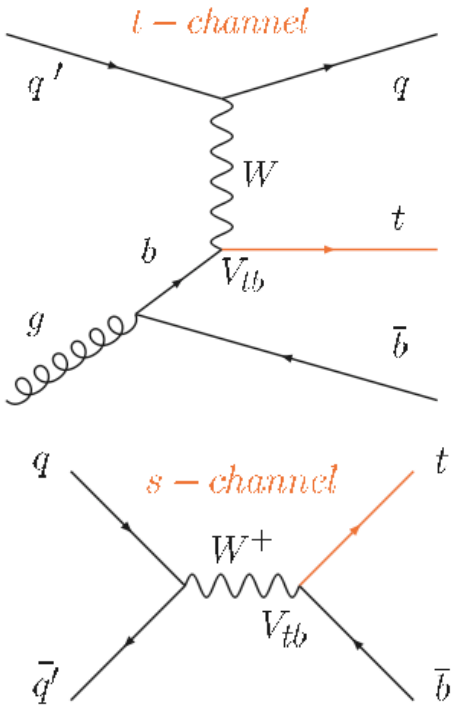
# Jet cross sections

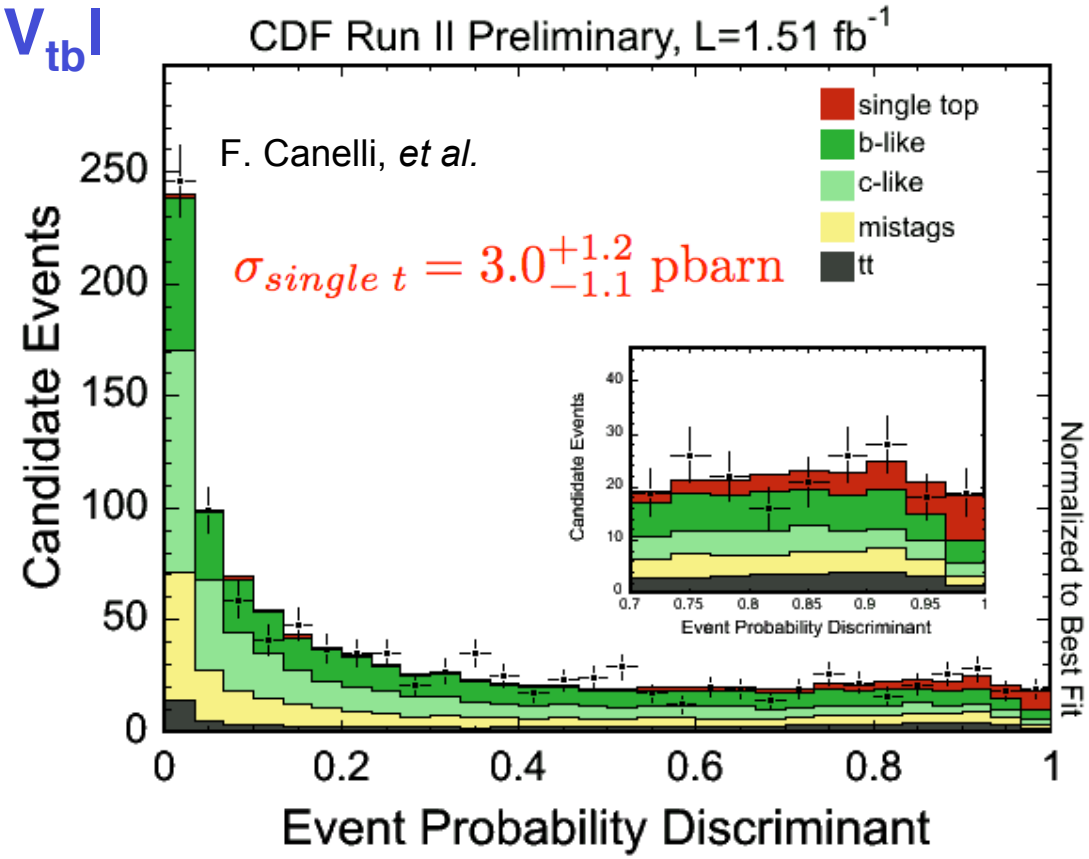



Data used to improve Parton Density Functions (PDF)

# Single Top Production

- **Cross Section Measurement**
- **Measurement of $|V_{tb}|$**

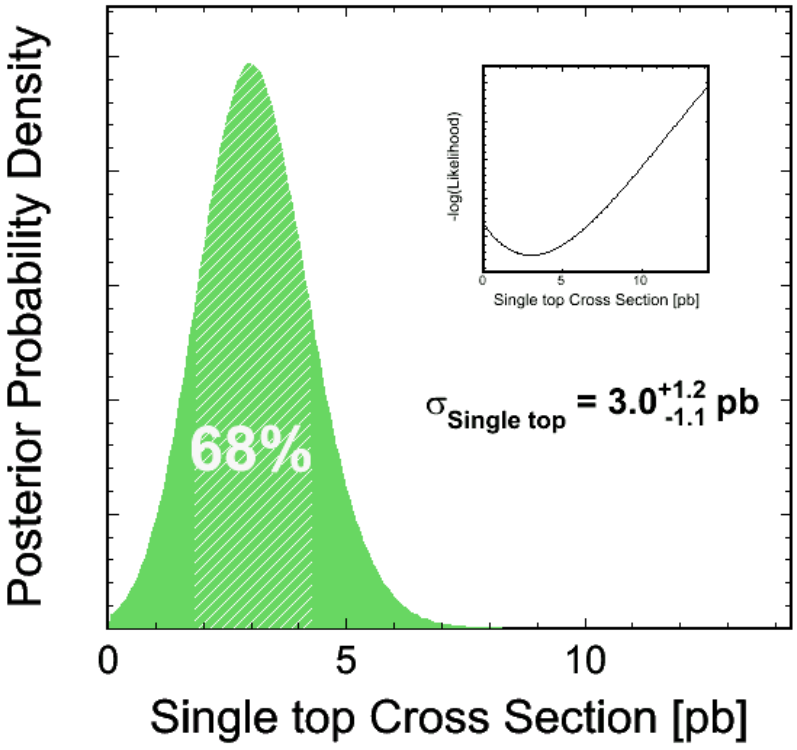


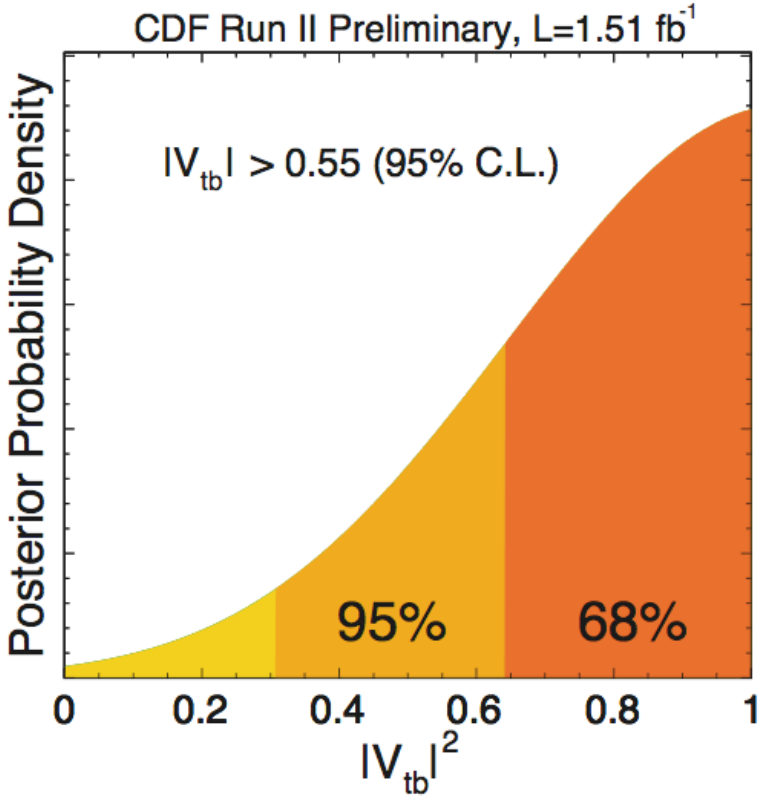



# Single Top Cross Section

- **Direct $|V_{tb}|$ measurement**

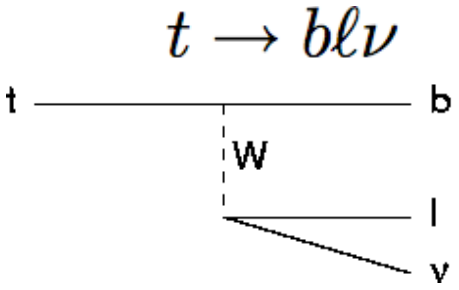
$$|V_{tb}| = 1.02 \pm 0.18(exp.) \pm 0.07(th.)$$

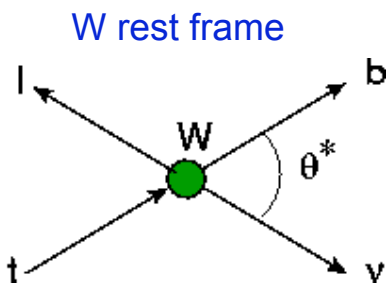


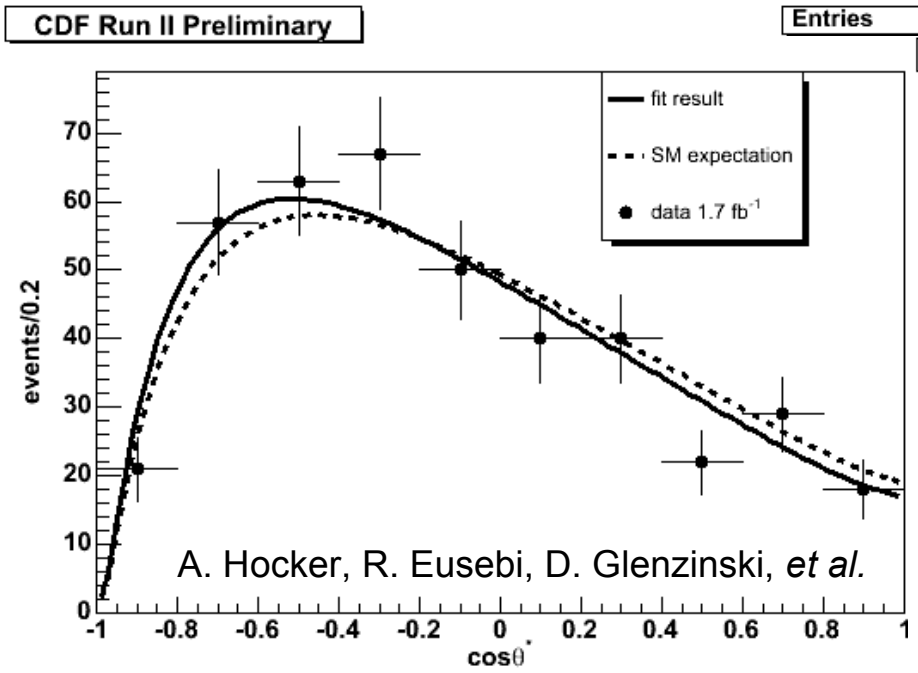



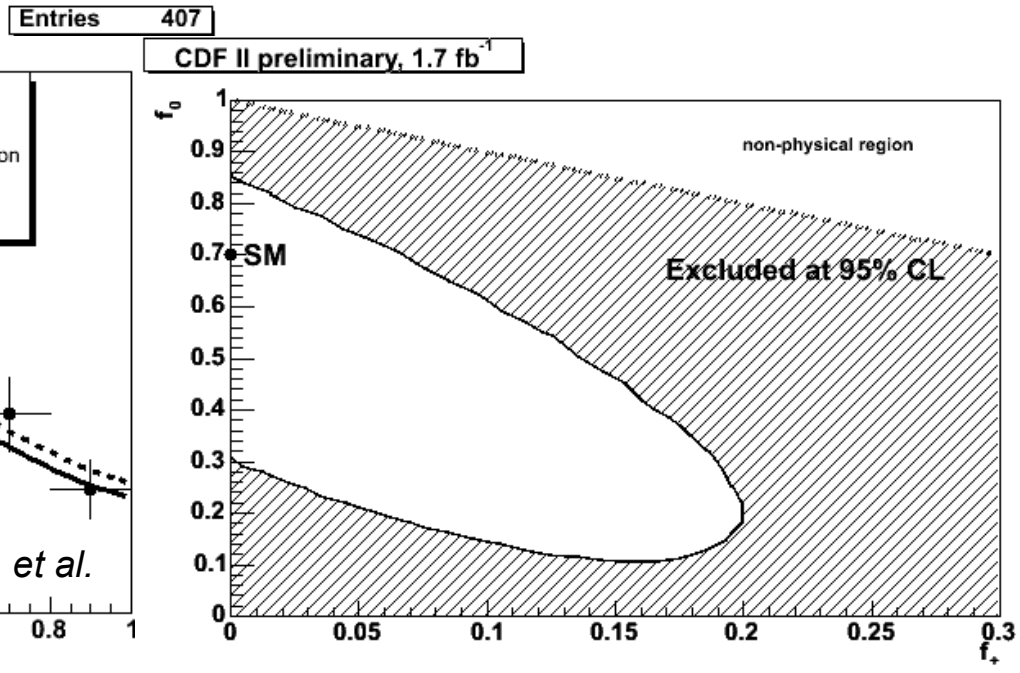
# W Polarization in t Decays

- **Study t,b,W vertex**
- **$f_+$,$f_0$ measure components of W polarization**



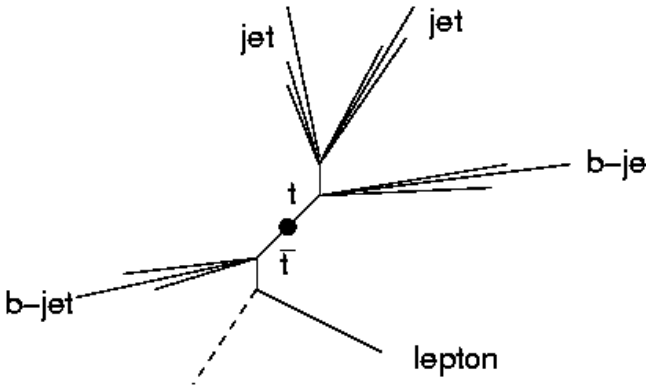



# Top Quark Mass

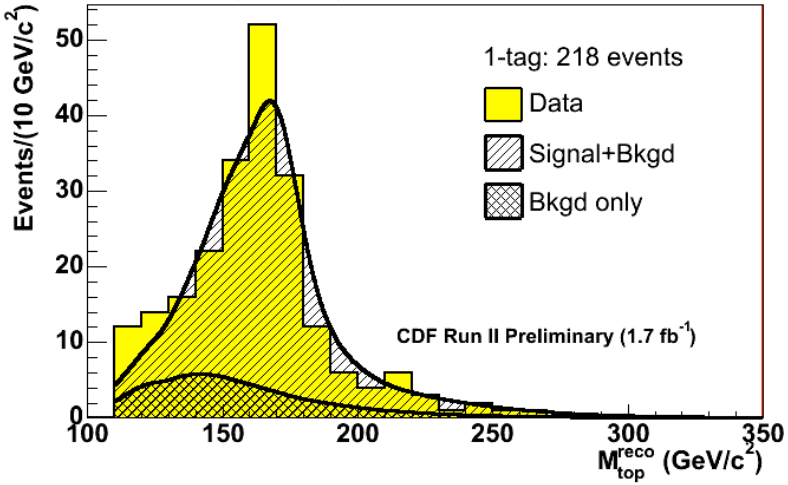
- **Top mass in t->W b decays**
- **Lepton+ jets: decay mode with highest mass precision (only 1 missing neutrino)**

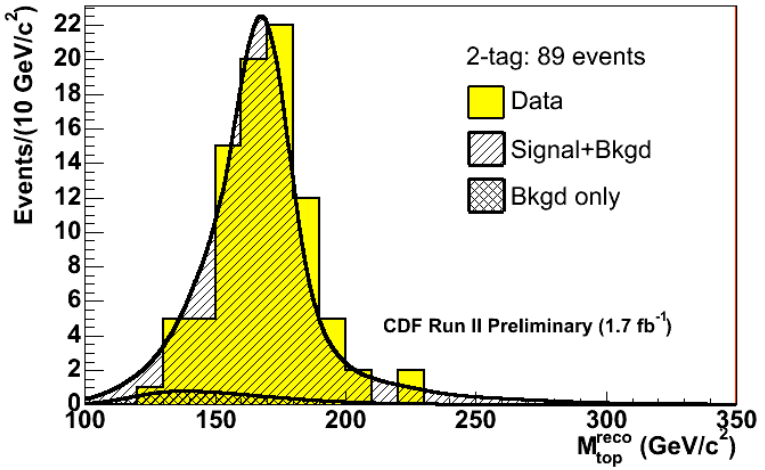



Mass, Jet energy scale templates

$171.6 \pm 2.1(stat) \pm 1.1(syst)\ \mathrm{GeV/c^2}$

G. Velev, *et al.*, 1.7 fb$^{-1}$

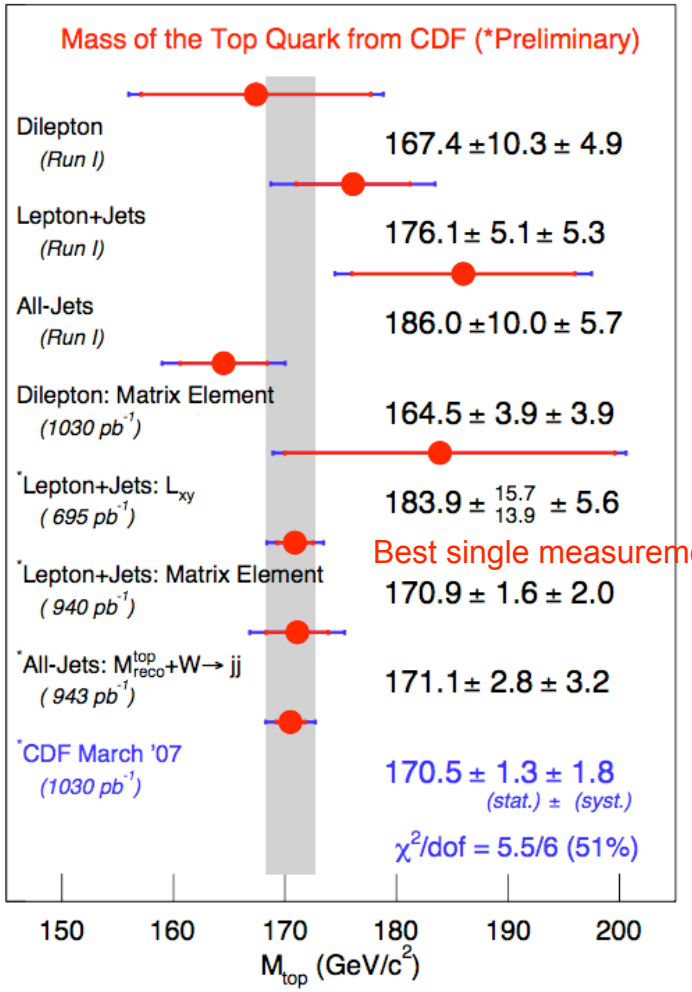


# Top Quark Mass

- **Advanced fitting techniques leads to worlds best measurement (lepton+jets)**
- **Constrained kinematics and ttbar cross section leads to worlds best $M_t$ in dilepton channel**
  - **Improved techniques leading to more precise measurements**
  - **Contributions from FNAL personnel**

March 2007

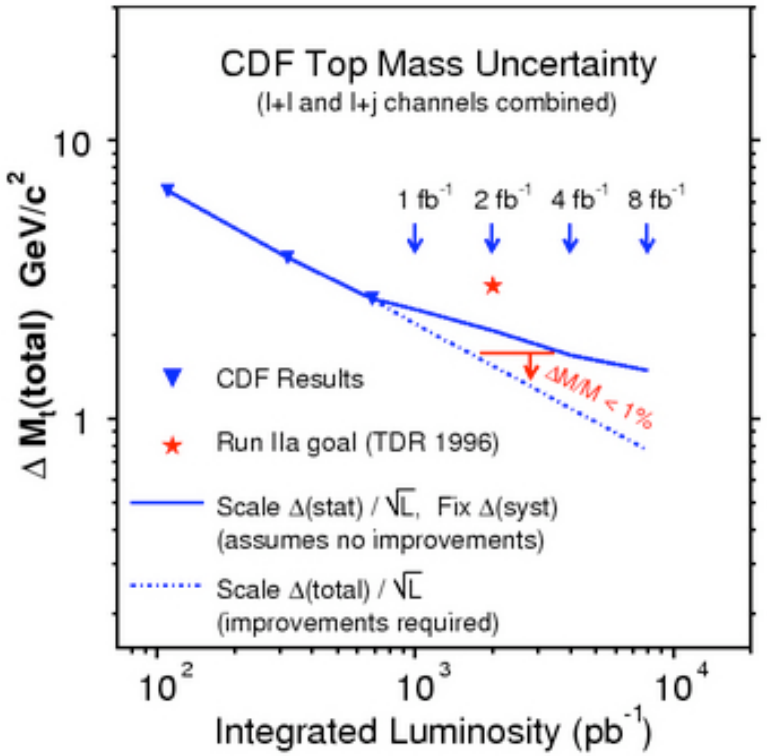


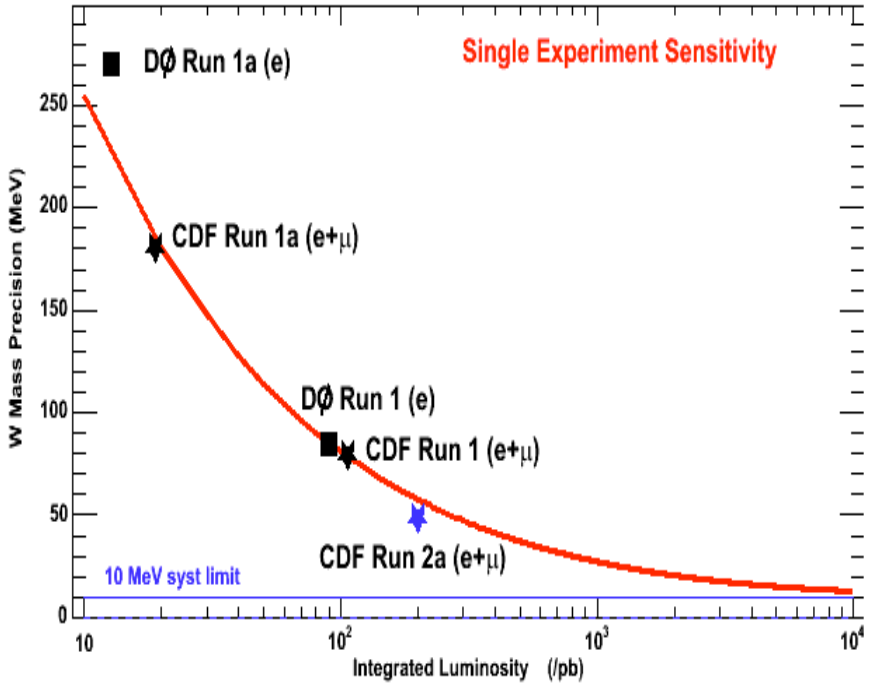

F. Caneli, *et al.*,

A. Beretvas, *et al.*, June 2007: 1.7 fb$^{-1}$

$$170.7^{4.2}_{3.9}(stat) \pm 2.6(syst) \pm 2.4(theory)$$

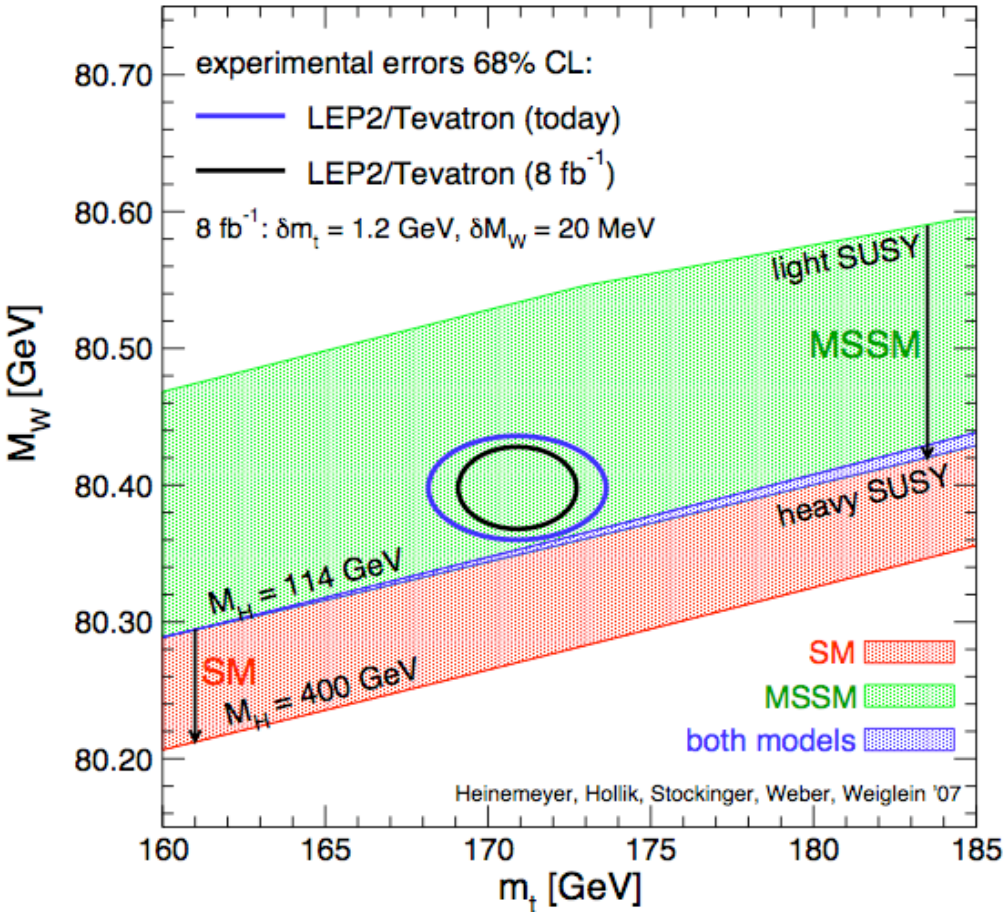
# Top, W Mass Prospects



# Toward Higgs:

- **Precise electroweak measurements narrow search window for Higgs**
- **Current analysis efforts lead naturally to Higgs search**



# Summary

- Recording large data sets with improved detector and high luminosity
- Fermilab group very productive
  - New particle observations
  - Limits on new physics
  - Top quark properties
  - Narrowing search window for Higgs
- Exciting time for physics